Response to Anonymous Referee #2 Received and published: 16 March 2021

I am sorry I took so long for reviewing this paper. This is not due to the topic the paper deals with but the way the paper is organised. I do not want to appear definitive, however, if the topic, of adapting the representation of a river network at certain resolution to be the more effective as possible, is of geographical interest, I am still not convinced it is also of hydrological importance. The Authors should work a little more to make the paper more appealing, instead they buried the good ideas under a lot of technicalities which are, certainly, important but secondary to the reasons why they do it. Finally some light came in with Figure 7 and 8 that clarified to me that the major errors can be caused in local contributing area estimation causing a subsequent wrong estimation of hydrograph. To this respect the paper shows that its method brings in quite an improvement in some simulations. Therefore my overall judgment is that the matter is good, but the organization of the paper highly improvable.

We appreciate the time you took to review our manuscript and are happy to read that you find the content good and agree the method has benefits for hydrological simulations. We will address your points of concern in more detail in the following responses. Most importantly, we have tried to clarify some points in the introduction and tried to make the structure of the paper more appealing.

I suggest to move in evidence the results and let the details to Appendix or to the final part of the paper. To simplify, I suggest to exchange the position of section 4 and section 2, after a preliminary, but brief discussion, of the methods. I understand that this may sound quite a violation of the traditional organization of papers, but I feel that probably in this way the paper should be more appealing to the reader.

We agree the paper is rather technical, but would like to argue that the purpose of the paper was to present and demonstrate a new method, which falls in scope with HESS. We disagree that our new method is not of "hydrological importance". We have demonstrated that our method significantly and positively influences the quality of direction of streams within a network, and as a consequence, also simulated peak discharge timing and magnitude. We have made some changes to the manuscript to clarify this and to make the structure more appealing:

- We have clarified the purpose of the paper as well as the relevance of good flow direction data and flow direction upscaling methods better in the introduction. As explained above, the purpose is firstly the presentation and secondly the demonstration for river routing of the new method.
- This is largely supported by the chosen structure, which is why we have decided not to change the structure significantly, but to resent the technicalities of the new method in a new section "2. Iterative Hydrography Upscaling" before section "3. Methods" which deals with the benchmark and synthetic runoff experiment
- We have added a more high-level introduction to "2. Iterative Hydrography Upscaling" to provide the reader with some more guidance before diving into the technicalities.

The epitome if it is the Caption of Figure 1. The phrase "for each cell the representative river pixel (dark red square) inside the effective area (shaded area) and subsequently the outlet pixel (orange square) is identified, and 1B) based

on the fine-resolution flow path downstream of the outlet pixel (black lines)," should become: "for each cell, based on the fine-resolution flow path downstream of the outlet pixel (black lines), the representative river pixel (dark red square) inside the effective area (shaded area) and subsequently the outlet pixel (orange square) is identified". The latter form of the phrase makes me understand what they are doing, not the reverse. The explanation in the text, indeed is much more clear than the caption of the Figure, but because I tried to understand first the procedure from the Figure, I had to read more times all of it to understand what was the point.

While we have put a lot of effort in creating an explaining figure, it remains difficult to summarize the entire method in a caption. We understand this sentence is unclear and have modified it to read: “Firstly, 1A) the representative river pixel (dark red square) inside the effective area (shaded area) and the outlet pixel (orange square) are identified for each cell based on upstream area, then 1B) the fine-resolution flow path downstream of the outlet pixel (black lines) is traced to a neighboring cell, 1C) to set the initial flow direction (orange arrow)”

For what regards the errors they find in flood forecasting, while I find interesting the idea that the coarse graining of the river network topology should be made to preserve the main characteristics of the flood wave, It is not clear to me how the errors (except maybe for those connected with the estimation of the contributing areas which bring with them a proportional error in rainfall inputs) were not corrected, at least partially, by a calibration. In my experience, the standard procedure for any hydrological modelling run follows the procedure of calibrating the model parameters and then validating them. The process of calibration, I am sure, introducing effective quantities for instance in those parameters related to flow velocities, can correct delays or anticipations of the flood wave due to a wrong estimation of stream length. Differently would be a problem, since the fractality of rivers. To say in another way, their argument to favor their method of river network representation, could be not so relevant at the end, for modelling. OVERFITTING physical realistical.

The aspect of model calibration can indeed resolve some errors related to incorrect representation of river parameters. Errors in upstream river length can potentially be compensated by manning roughness values using calibration. Other local errors in the flow direction data, such as a confluence which is located upstream from the actual position, will however lead to large local errors which cannot be compensated by calibrating other river parameters as the distribution of the runoff is simply incorrect. But more important, using calibration to compensate for erroneous data in your model will likely lead to improved simulations but for the wrong reasons (it might for instance take physically unrealistic manning parameters to compensate for errors in river length) and will likely lead to overfitting of the model which might decrease its performance outside the range of the calibration data (Hrachowitz et al., 2013; Kirchner, 2006).

A last note regards the subgrid representation of the networks. I found the paper by V. Casulli (2019) of real interest for the issue.

Thanks for this interesting reference.

In summary I believe the paper can be accepted after a major readjusting of its structure.

Thank you - we have adjusted the structure as summarised in response to earlier comment.

References:

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